How to obtain ocean turbulent dynamics at super resolution from optimal multiresolution analysis and multiplicative cascade?

Joël Sudre, Hussein Yahia, Oriol Pont, Veronique Garcon

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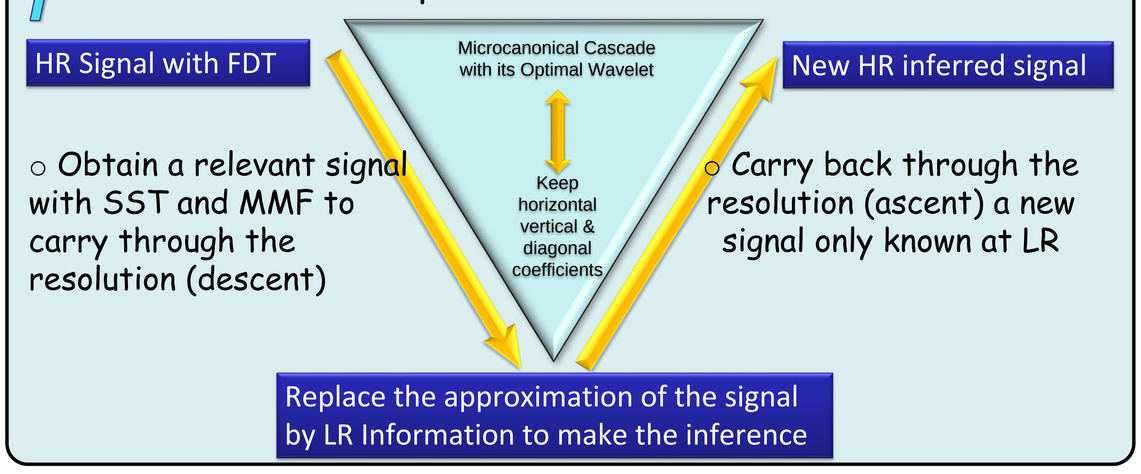
J. Sudre[1], H. Yahia[2], O. Pont[2], V. Garçon[1]
[1]LEGOS/CNRS, France
[2]INRIA Centre-Bordeaux Sud-Ouest, France

Abstract

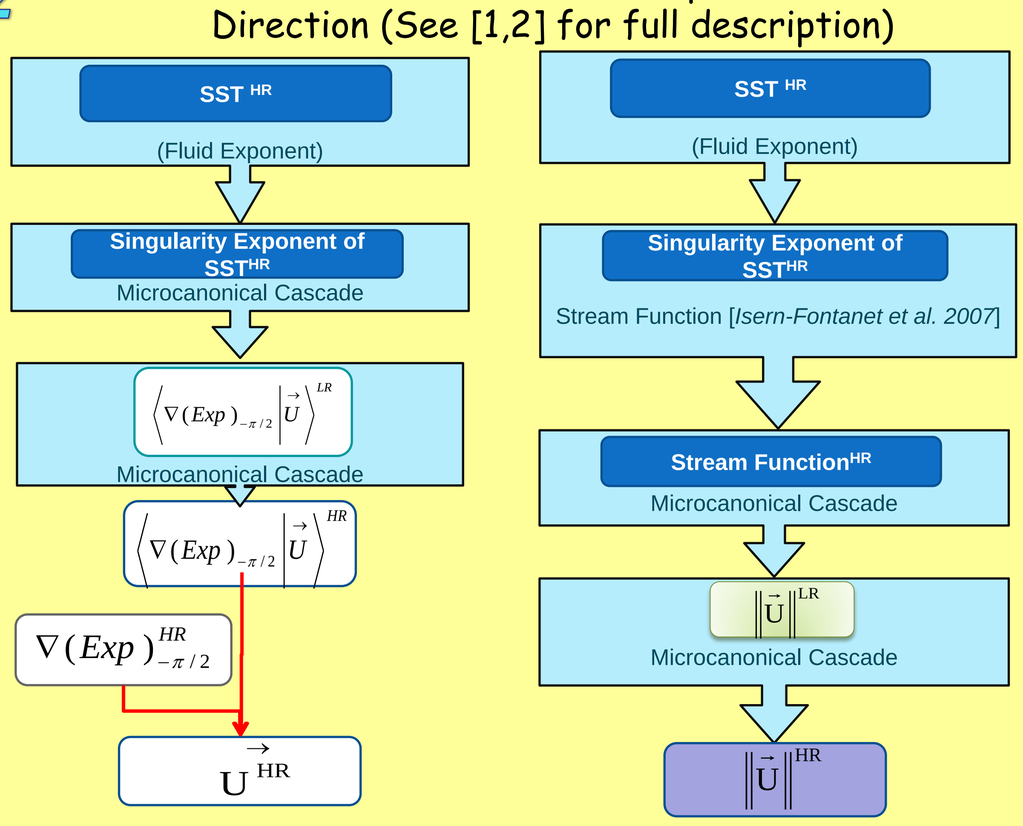
A fundamental challenge in oceanography is the **synoptic determination of ocean circulation** using the data acquired from space, **with a coherent depiction of its turbulent characteristics**. This determination has the potential of revealing all aspects of the ocean dynamic variability on a wide range of spatio-temporal scales and will enhance our understanding of ocean–atmosphere exchanges at super resolution, as required in the present context of climate change.

- New method based on an **approximation of the energy of Microcanonical Cascade (MC)**, expressed in a **Multiscale Microcanonical Formulation (MMF)**, associated to turbulent signals provided by different Sea Surface Temperature (SST) or Ocean Color (Chl-a) products.
- **The approach** offers the opportunity to infer different oceanic turbulent signals from Low Resolution (LR) to HR. Basic idea:
  - **optimal cascading** to decrease the spatial resolution of the HR signal (adimensional critical transition informations of SST),
  - use the signal available at LR (GEKCO product at 1/4° [1]), **transmit that information along the scales back** to higher spatial resolution using the cascade to obtain a new HR signal.
- The process has been successfully used **to obtain oceanic currents** at 1/24° [2] and 1/64°.

1 General concept of the MMF/MC method



2 To obtain Oceanic current at HR : Separation of Norm and Direction (See [1,2] for full description)



3 To validate oceanic current at HR (4 years period): Use drifters during the period January 1, 2006 to December 31, 2009. (more validation tests in [2])

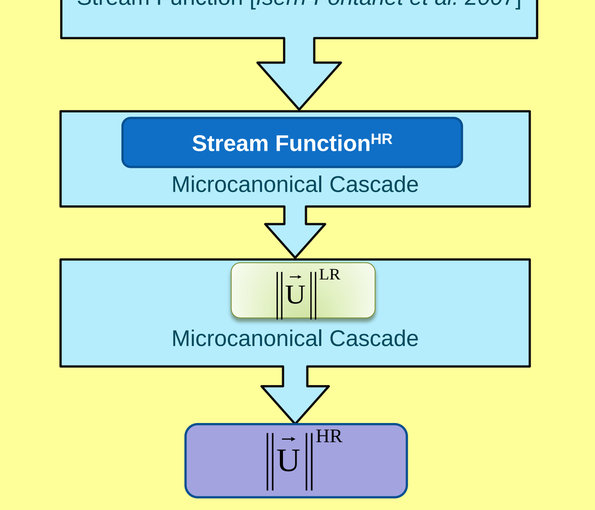
Positions of the 373 drifters drogued at a 15 m depth coming from Global Drifter Program at the AOML (925712 points)

Computation of : $\|a\| - \|b\|$ Where:

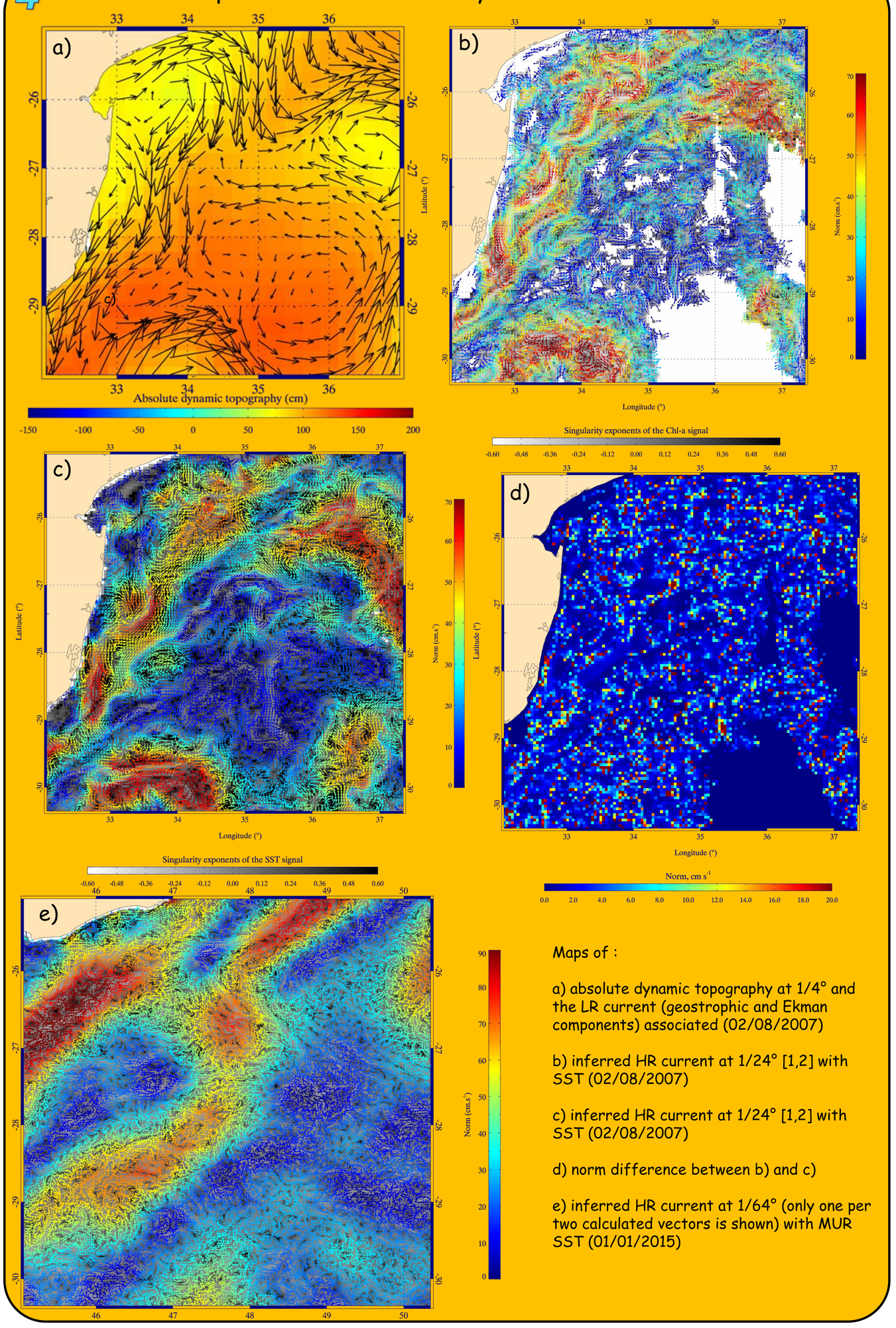
$$\mathbf{a} = \frac{1}{\sharp(\mathcal{M}_{\mathcal{X}}^b)} \sum_{i=1}^{\sharp(\mathcal{M}_{\mathcal{X}}^b)} \frac{\mathbf{u}_i^b}{\|\mathbf{u}_i^b\|}$$

$$\mathbf{b} = \frac{1}{\sharp(\mathcal{M}_{\mathcal{X}}^b)} \sum_{i=1}^{\sharp(\mathcal{M}_{\mathcal{X}}^b)} \frac{\mathbf{w}_i^b}{\|\mathbf{w}_i^b\|}$$

$\mathbf{u}_i^b$, $\mathbf{w}_i^b$: Recorded buoy and computed velocities



4 Examples of data obtained by the MMF/MC method



Maps of :

a) absolute dynamic topography at 1/4° and the LR current (geostrophic and Ekman components) associated (02/08/2007)

b) inferred HR current at 1/24° [1,2] with SST (02/08/2007)

c) inferred HR current at 1/24° [1,2] with SST (02/08/2007)

d) norm difference between b) and c)

e) inferred HR current at 1/64° (only one per two calculated vectors is shown) with MUR SST (01/01/2015)

Conclusion and Future Work

- **Evidencing multiscale geometric structures in synthetic ROMS data and satellite data data through the Multiscale Microcanonical Formalism**
- **Validation of algorithms on synthetic ROMS data**
- **Application of the algorithms on satellite data**
- **Validation of the new HR satellite data with *in-situ* data**

- **Future Work: - Analyze the difference between SST and Chl-a inferred HR currents for the 4 years period**
  - Process and validate SST HR currents at 1/64° on global area

References

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- [2] J. Sudre, H. Yahia, O. Pont, and V. Garçon, 2015, Ocean turbulent dynamics at superresolution from optimal multiresolution analysis and multiplicative cascade, IEEE TGRS, DOI: 10.1109/TGRS.2015.2436431

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